P. minus, though the former is much the larger. Such then are the facts as they appear from Cuvier's writings. The fact that this one skeleton of *P. minus* was found with the neck in the erect position may have been considered by Cuvier as hardly a sufficient reason for placing the neck of his restored specimen, which showed so many tapiroid peculiarities, in the same position. Now, however, that a second skeleton of a *Palæotherium* has been found, with the neck in a similar position, the probability that such a position is the natural one is immensely enhanced.

Two points, however, remain somewhat involved in obscurity ; first, how is it that the skeleton of *P. magnum*, as found at Vitry-sur-Seine the other day, differs so much in the length of its leg-bones from the *P. magnum* of Cuvier, which it undoubtedly does if the drawings and descriptions of both are correct? and secondly, how was it that Cuvier, with such a perfect skeleton as that in the accompanying figure, should restore an animal with such short and comparatively stout legs?

Someone perhaps may be able to throw some light upon these points. W. BRUCE-CLARKE

The Telegraph in Storm-warnings

THE idea of using the electric telegraph to give warning of cyclones approaching from a distance is generally supposed to have first occurred to Prof. Henry of the Smithsonian Institution in 1847 (NATURE, vol. iv. p. 390). This however is not the fact, for the same thing had been recommended in India fully five years before by the late Mr. Henry Piddington, in his sixth "Memoir on the Law of Storms," published in the Journal of the Asiatic Society of Bengal in 1842. Referring to a storm which was tracked from Macao to Shih-poo, and its estimated rate of travelling, he says (p. 703) :—"If China was a country under European dominion, a telegraph might, when these storms strike the eastern coast, warn those on the southern that they were coming, and in India we might often attain the same advantage. *Our children may see this done.*" In 1849, when he published the first edition of his "Sailor's Horn-Book for the Law of Storms," he had not yet heard of the fulfilment in America of his prophecy, which however he has duly noticed in subsequent editions. FRED. NORGATE

Corydalis claviculata

A SHORT additional note on *Corydalis claviculata* may be of interest. A sprig placed in a glass of water and out of the way of insects continues to grow and to bear flowers and fruit with nearly as much regularity as if still rooted to its native bank. The flowers do not gape spontaneously; and, as most of the older ones that I have examined in a state of nature have their lips depressed, I think it certain evidence of the agency of insects, though I have not yet been so fortunate as to witness their operations. All the flowers that I have seen are of a greenish white, but dried specimens acquire the yellow tint described in systematic works, a fact which may help to throw light on the somewhat parallel behaviour of *Fumaria pallidiflora*.

Kilderry, co. Donegal W. E. HART

POLARISATION OF LIGHT[*]

IX.

THE results of combining two or more colours of the spectrum have been studied by Helmholtz, Clerk Maxwell, Lord Rayleigh, and others. And the combinations have been effected sometimes by causing two spectra at right angles to one another to overlap, and sometimes by bringing images of various parts of a spectrum simultaneously upon the retina. Latterly also W. von Bezold has successfully applied the method of binocular combination to the same problem (*Poggendorff*, Jubelband, p. 585). Some effects, approximating more or less to these, may be produced by chromatic polarisation.

Complementary Colours.—First, as regards complementary colours. If we use a Nicol's prism N as polariser, a plate of quartz Q cut perpendicularly to the axis, and a double-image prism P as analyser, we shall, as is well known, obtain two images whose colours are complementary. If we analyse these images with a prism, we shall find when the quartz is of suitable thickness, that each spectrum contains a dark band indicating the extinction of a certain narrow portion of its length. These bands will simultaneously shift their position when the Nicol N is turned round. Now, since the colours remaining in each spectrum are complementary to those in the other, and the portion of the spectrum extinguished in each is complementary to that which remains, it follows that the portion extinguished in one spectrum is complementary to that extinguished in the other. And in order to determine what portion of the spectrum is complementary to the portion suppressed by a band in any position we please, we have only to turn the Nicol N until the band in one spectrum occupies the position in question, and then to observe the position of the band in the other spectrum. The combinations considered in former experiments are those of simple colours ; the present combinations are those of mixed tints, viz. of the parts of the spectrum suppressed in the bands. But the mixture consists of a prevailing colour corresponding to the centre of the band, together with a slight admixture of the spectral colours immediately adjacent to it on each side.

The following results given by Helmholtz, may be approximately verified :—

Complementary Colours	
Red	Green-blue
Orange	Cyanic blue
Yellow	Indigo-blue
Yellow-green	Violet

When in one spectrum the band enters the green, in the other a band will be seen on the outer margin of the red, and a second at the opposite end of the violet ; showing that to the green there does not correspond one complementary colour, but a mixture of violet and red, *i.e.* a reddish purple.

Combination of two Colours.—Next as to the combination of two parts of the spectrum, or of the tints which represent those parts. If, in addition to the apparatus described above, we use a second quartz plate Q_1 and a second double-image prism P_1, we shall form four images, say O O, O E, E O, E E. And if A, A′ be the complementary tints extinguished by the first combination Q P alone, and B, B′ those extinguished by the second Q_1 P_1 alone, then it will be found that the following pairs of tints are extinguished in the various images.

Image	Tints extinguished
O O	B, A
O E	B′, A′
E O	B′, A
E E	B, A′

It is to be noticed that in the image O E the combination Q_1 P_1 has extinguished the tint B′ instead of B, because the vibrations in the image E were perpendicular to those in the image O formed by the combination Q P. A similar remark applies to the image E E.

The total number of tints which can be produced by this double combination Q P, Q_1 P_1 is as follows :—

4 single images
6 overlaps of two
4 overlaps of three
1 overlap of four

Total, 15

Collateral Combinations.—The tints extinguished in the overlap O O + E O will be B, A, B′, A ; but since B and B′ are complementary, their suppression will not affect the resulting tint except as to intensity, and the overlap will be effectively deprived of A alone ; in other words, it will be of the same tint as the image O would be if the combination Q_1 P_1 were removed. Similarly the overlap O E + E E will be deprived effectually of A′ alone ; in other words, it will be of the same tint as E, if Q_1 P_1 were removed. If therefore the Nicol N be turned round, these two overlaps will behave in respect of colour exactly as did the images O and E when Q P was alone used. We may, in fact, form a table thus :—

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[*] Continued from vol. ix. p. 508.

Image	Colours extinguished
O O + E O	$B + A + B' + A = B + B' + A = A$
O E + E E	$B' + A' + B + A' = B + B' + A' = A'$

And since the tints B, B′ have disappeared from each of these formulæ, it follows that the second analyser P may be turned round in any direction without altering the tints of the overlaps in question.

In like manner we may form the Table—

O O + E E	$B + A + B + A' = B + A + A' = B$
O E + E O	$B' + A' + B' + A = B' + A + A' = B'$

Hence if the Nicol N be turned round, these overlaps will retain their tints; while if the analyser P_1 be turned, their tints will vary, although always remaining complementary to one another.

There remains the other pair of overlaps, viz.:—

O O + O E	$B + A + B' + A$
E O + E E	$B' + A + B + A'$

Each of these is deprived of the pair of complementaries A, A′, B, B′; and therefore each, as it would seem, ought to appear white of low illumination, *i.e.* grey. This effect is, however, partially masked by the fact that the dark bands are not sharply defined like the Fraunhofer lines, but have a core of minimum or zero illumination, and are shaded off gradually on either side until a short distance from the core the colours appear in their full intensity. Suppose, for instance, that B′ and A′ were bright tints, the tints resulting from their suppression would be bright. On the other hand, the complementary tints A and B would be generally dim, and the image $B + A$ bright, and the overlap $B + A + B' + A'$ would have as its predominating tint that of $B + A$. And similarly in other cases.

There are two cases worth remarking in detail, viz. first, that in which

$$B = A', B' = A$$

i.e. when the same tints are extinguished by the combination Q P and by Q_1 P_1. This may be verified by either using two similar quartz plates Q, Q_1; or by so turning the prism P_1 that the combination Q_1 P_1 used alone shall give the same complementary tints as Q P when used alone. In this case the images have for their formulæ the following:—

O O	O E	E O	E E
$A + A'$	$A + A'$	$2A$	$2A'$

in other words, O O and E O will show similar tints, and E O, E E complementary. A similar result will ensue if $B = A$, $B' = A'$.

Again, even when neither of the foregoing conditions are fulfilled, we may still, owing to the breadth of the interference bands, have such an effect produced that sensibly to the eye

$$B + A = B' + A'$$

and in that case

$$\begin{aligned} B' + A &= B + A - A' + A \\ &= B + A' + 2A - 2A' \end{aligned}$$

which imply that the images O O and O E may have the same tint; but that E O and E E need not on that account be complementary. They will differ in tint in this, that E E, having lost the same tints as E O, will have lost also the tint A, and will have received besides the addition of two measures of the tint A′.

Effect of Combination of two Colours.—A similar train of reasoning might be applied to the triple overlaps. But the main interest of these parts of the figure consists in this, that each of the triple overlaps is complementary to the fourth single image; since the recombination of all four must reproduce white light. Hence the tint of each triple overlap is the same to the eye as the mixture of the two tints suppressed in the remaining image. And since by suitably turning the Nicol N or the prism P_1, or both, we can give any required position to the two bands of extinction, we have the means of exhibiting to the eye the results of the mixture of tints due to any two bands at pleasure.

Effect of Combinations of three Colours.—A further step may be made in the combination of colours by using a third quartz Q_2 and a third double-image prism P_2, which will give rise to eight images. And if C C′ be the complementaries extinguished by the combination Q_2 P_2, the formulæ for the eight images may be thus written:—

O O O	$C + B + A$
O O E	$C + B' + A'$
O E O	$C' + B' + A$
O E E	$C' + B + A'$
E O O	$C' + B + A$
E O E	$C' + B' + A'$
E E O	$C + B' + A$
E E E	$C + B + A'$

The total number of combinations of tint given by the compartments of the complete figure will be

$\frac{8}{1}$	= 8 single images		
$\frac{8 . 7}{1 . 2}$	= 28 overlaps of two		
$\frac{8 . 7 . 6}{1 . 2 . 3}$	= 56	„	three
$\frac{8 . 7 . 6 . 5}{1 . 2 . 3 . 4}$	= 70	„	four
$\frac{8 . 7 . 6}{1 . 2 . 3}$	= 56	„	five
$\frac{8 . 7}{1 . 2}$	= 28	„	six
$\frac{8}{1}$	= 8	„	seven
1	= 1	„	eight
Total . .	255		

The most interesting features of the figure consists in this, that the subjoined pairs are complementary to one another, viz.:—

O O O $C + B + A$	E O E $C' + B' + A'$
E O O $C' + B + A$	O O E $C + B' + A'$
E E O $C + B' + A$	O E E $C' + B + A'$
E E E $C + B + A'$	O E O $C' + B' + A$

And if the prisms P, P_1, P_2 are so arranged that the separations due to them respectively are directed parallel to the sides of an equilateral triangle, the images will be disposed thus:—

	O E O	O O O	
E E O	E O O	O E E	O O E
	E E E	E O E	

The complementary pairs can then be read off, two horizontally and two vertically, by taking alternate pairs, one in each of the two vertical, and two in the one horizontal row. And each image will then represent the mixture of the three tints suppressed in the complementary image.

Low-tint Colours.—A slight modification of the arrangement above described furnishes an illustration of the conclusions stated by Helmholtz, viz. that the low-tint colours (couleurs degradées), such as russet, brown, olive-green, peacock-blue, &c., are the result of relatively low illumination. He mentioned that he obtained these effects by diminishing the intensity of the light in the colours to be examined, and by at the same time maintaining a brilliantly illuminated patch in an adjoining part of the field of view. If therefore we use the combination N, Q, P, P_1 (*i.e.* if we remove the second quartz plate), we can, by turning the prism round, diminish to any required extent the intensity of the light in one pair of the complementary images, and at the same time increase that in the other pair. This is equivalent to the conditions of Helmholtz's experiments; and the tints in question will be found to be produced.

W. SPOTTISWOODE

VENUS'S FLY-TRAP (*Dionæa muscipula*) *

II.

Contractility of Dionæa.—I have given you a general view of our plant and of its behaviour. We next proceed to examine more particularly that property of contracting when irritated to which the plant owes its faculty of catching insects, and to which my own investigations have been directed. Before beginning the experimental demonstration of the facts, I wish to lay before you some considerations relating to the nature of this property as it manifests itself in living beings belonging to both kingdoms.

We have to do here not merely with contractility but with irrito-contractility. The fact that the property requires two words to express it implies that there are two things to express, viz. (1) that contraction takes place, and (2) that it takes place in answer to irritation. As this is the case not only here, but in all other instances of animal or vegetable active motion, we recognise in physiology these two properties as fundamental: irritability, or *excitability*, and *contractility*, the former designating the property possessed by every living structure whatsoever of being excited to action (*i.e.* of having its stored-up force discharged) by some motion or disturbance from outside; the latter, that kind of discharge or action which results in change of form, and usually declares itself in the doing of mechanical work. This property of excitability, which, let me repeat, is common to all living structures, is, as we have seen, comparable in its simplest manifestations to that possessed by many chemical compounds (of explosiveness) and many mechanical contrivances (of going off or discharging when meddled with, as in the case of the rat-trap already referred to).

In physiology, as in the other sciences of observation, the process of investigation is, throughout, one of comparison. Not only do we proceed from first to last from the known towards the unknown, but what we speak of as our knowledge or understanding of any new fact consists simply in our being able to bring it into relation with other facts previously well ascertained and familiar, just as the geographer determines the position of a new locality by ascertaining its topographical relation to others already on the chart.

The comparison we have to make this evening is between the contractility displayed by the leaf of Dionæa and the contractility of muscle. I choose muscle as the standard of comparison, not merely because it is best known and has been investigated by the best physicists of our time, but because its properties are easily illustrated and understood. I shall be able to show that the resemblance between the contraction of muscle and that of the leaf is so wonderfully complete that the further we pursue the inquiry the more striking does it appear. Whether we bring the microscope to bear on the structural changes which accompany contraction, or employ the still more delicate instruments of research which you have before you this evening, in order to determine and measure the electrical changes which take place in connection with it, we find that the two processes correspond in every essential particular so closely, that we can have no doubt of their identity.

Muscle, like every other living tissue, is the seat, so long as it lives, of chemical changes, which, if the tissue is mature, consist entirely in the disintegration of chemical compounds and the dissipation of the force stored up in these compounds, in the form of heat or some other kind of motion. This happens when the muscle is at rest, but much more actively when it is contracting, in which condition it not only produces more heat than it produces at other times, but also may do—and, under ordinary circumstances, does—mechanical work; these effects of contraction of muscle are, of course, dependent in quantity on the chemical disintegration which goes on in its interior.

Again, muscle so long as it is in the living state is electromotive. This property it probably possesses in common with other living tissues, for it is very likely that every vital act is connected with electrical change in the living part. But in muscle, as well as other irritable and contractile tissues in animals, the manifestation of electromotive force is inseparably connected with the special function of the tissue, *i.e.* with contraction, the connection being of such a nature that the electromotive force expresses, not the work actually done at any given moment, but the capacity for work. Thus, so long as the muscle lives, its electromotive force is found to be on the whole proportional to its vigour. As it gradually loses its vitality, its power of contracting and its electromotive force disappear *pari passu*. When it contracts, the manifestation of electromotive force diminishes in proportion to the degree of contraction. But it is to be borne in mind that, although when the muscle or the leaf contracts electromotive force disappears and work is done, there is no reason for supposing that there is any conversion of the one effect into the other, or that the source of the force exercised by the organ in contracting is electrical.

The lecturer then proceeded to demonstrate the correspondence between the electrical phenomena which accompany muscular contraction, and those which are associated with the closing of the Dionæa leaf, by a series of experiments.*

1. The form of the gastrocnemius muscle of the frog, in the uncontracted state, was projected on the screen with the aid of the electric light. A contraction was then determined by passing through it a single opening induction shock. It was seen to shorten and to become proportionately broader.

[In contraction, the bulk of a muscle remains unaltered. Further, the change of shape of the whole muscle depends on an exactly similar change of shape of every particle of which it is composed. This might be inferred from the consideration that a muscle is not an apparatus made up of parts differing from each other in structure, but a mass of substance equally instinct with life in every part. We know it to be the case by direct observation, for if we observe living muscle in the act of contraction under the microscope (as can easily be done in the muscles of insects), † we see that each minutest fibre participates in the change of form. The same holds good as regards the plant. The agent in the contraction is, without doubt, the protoplasm of the cells of the contractile organs. In Dionæa this has not as yet been sufficiently investigated, but in Drosera Mr. Darwin has shown that when the hairs which project from the upper surface of the leaf, become "incurved" under the exciting influence of appropriate stimuli, the contents of the cells undergo a most peculiar

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* Continued from p. 107.

* The statements contained in the first part of this lecture, especially those relating to the mechanism of the closure of the Dionæa leaf and its digestion, are founded almost entirely on information which I owe to Mr. Darwin. The experiments which led to the discovery of the "leaf current" and its "negative variation" were made last autumn, Mr. Darwin having kindly furnished me with plants for the purpose.—J. B. S.

† See Schäfer "On the Contraction of the Muscles of the Water-beetle, Phil. Trans., vol. clxiii. p. 429, 1873.